THE UNCONFORMITY AT THE BASE OF THE ONONDAGA LIMESTONE IN NEW YORK AND ITS EQUIVALENT WEST OF BUFFALO[1]

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INTRODUCTION

The importance of stratigraphic breaks has recently been emphasized by a geologist in the following words: "The discovery of such breaks, whether previously suggested by faunal evidence or not, is the most important duty of the progressive stratigrapher."[2] If the demonstration of these breaks is included as a part of the duty of the stratigrapher, most geologists will heartily agree with this sentiment. Stratigraphic breaks not fully supported by evidence have much the same status in geology as have new species which have been discovered but not figured or described. They may or may not be genuine, but in either case they are outside the pale of science until their sponsor has submitted valid evidence of their existence.

The present paper is intended as a contribution to the demonstration and synthetic discussion of a particular unconformity. A stratigraphic break with so great a lateral extent as the one separating the Onondaga and pre-Onondaga sediments merits a more detailed description than it has yet received. The disconformity[3] at the base of the Onondaga limestone, although previously known in western New York[4] and Ontario,[5] has not hitherto been

[1] Published with the permission of the Director of the U.S. Geological Survey and the Director of the Canadian Geological Survey.

[2] *Bull. Geol. Soc. Am.*, XXII (1911), 541.

[3] The term disconformity will be used in the sense proposed by Dr. Grabau (*Science*, N.S., XXIX [1905]) where it is applicable in this paper; but it passes, as will be shown, into a clino-unconformity (Crosby, *Jour. Geol.*, XX [1912], 296) in its western phase. The broader term unconformity is used to include both types of stratigraphic break.

[4] J. M. Clarke, *Memoirs New York State Mus.*, No. 3 (1900), pp. 96–98; A. W. Grabau, *Bull. New York State Mus.*, No. 45 (1901), pp. 117–20.

[5] C. R. Stauffer, *Bull. Geol. Soc. Am.*, (1912), pp. 373–75.

shown to be coextensive with the stratigraphic break at the base of its western equivalents in Ohio and Indiana. It remains to point out the continuity of this break across a wide belt of country extending about 700 miles from eastern New York to the Ohio and Wabash rivers. The Onondaga age of certain sandy beds at the base of the Onondaga limestone in New York which have generally been referred to the Oriskany will also be indicated.

NEW YORK

Eastern and central New York.—The unconformity at the base of the Onondaga though widely extended seems not to have been universal in eastern New York. In southeastern New York there appears to have been no interruption between the Esopus-Schoharie epoch of sedimentation and that of the Onondaga limestone. The fine grits of the former appear, as noted by Van Ingen,[1] to pass very gradually and almost imperceptibly into the impure limestone beds at the base of the latter without any indication of a physical break. There is, too, more resemblance between the fauna of the Onondaga and that of the preceding fine siliceous sediments than could be expected if a physical break had intervened between the periods of their deposition. The presence in the Onondaga of *Anoplotheca acutiplicata*, which is the only common fossil in the Esopus of southeastern New York and adjacent parts of New Jersey, is significant of uninterrupted sedimentation. The failure of many species of the Schoharie to persist into the Onondaga would, of course, be inevitable even with sedimentation uninterrupted, because of the marked difference in the two kinds of sediments and corresponding differences in the conditions under which they were laid down.

While in southeastern New York it appears that the Onondaga limestone sedimentation followed Schoharie sedimentation without interruption of marine conditions, in central and in a portion of eastern New York the evidence is conclusive that the Onondaga limestone was deposited over an extensive area which was submerged shortly before its deposition. Throughout central and western New York there is no trace of the 300 feet of Esopus

[1] *Bull. New York State Mus.*, No. 69, (1903), p. 1204.

and Schoharie formations which, in the Hudson and Delaware valleys, separate the Oriskany from the Onondaga above. In the east-central New York region the Onondaga limestone rests upon an old eroded land surface composed sometimes of the Oriskany sandstone, but much more frequently of limestone of the Helderberg group. The basal beds of the Onondaga if followed westward across New York are seen to rest successively on conformable Schoharie in southeastern New York, disconformable Oriskany sandstone and limestone of the Helderberg group and finally upon Silurian strata in the western part of the state. The physical evidence of the disconformity in this region includes both an irregular or angular contact surface between the Onondaga and subjacent beds and a basal sandstone or conglomerate. The latter is usually less than a foot thick and frequently comprises only a few inches of calcareous sandstone with occasional fragments of limestone from the Helderberg below. This sandy bed at the base of the Onondaga frequently grades upward into the limestone and gradually merges itself into it. The maps and reports which deal with the Devonian in central New York usually refer this basal sandy bed beneath the Onondaga limestone to the Oriskany. There can, however, be but little doubt that it represents reworked Oriskany sand. But it cannot properly be referred to the Oriskany because Oriskany fossils are absent and Onondaga fossils are frequently present in it. This thin basal sandstone band at the base of the Onondaga is well exposed at the Splitrock quarry southwest of Syracuse. At the east end of the Splitrock quarry the 4 or 5 ft. of Onondaga limestone is separated from the Helderberg below by a thin band of sandstone. The lower 2 in. of the sandy beds is probably 75 per cent sand in a calcareous matrix. The percentage of sand decreases and the lime increases upward gradually until all of the sand disappears within 1 ft. of the top of the Helderberg. Only about 6 in. of the sandy band at the base of the Onondaga could properly be called a sandstone and no sharp line of demarkation between this and the slightly less sandy base of the limestone could be drawn. The absence of Oriskany fossils from this basal sandstone and the presence in it of Onondaga corals at the very base of the bed clearly indicate that it belongs

with the Onondaga rather than the Oriskany sediments, as heretofore classed. In places in the eastern part of this quarry the basal bed of the Onondaga includes, in addition to fine sand, flat or oval fragments of the underlying limestone and, more rarely, a rounded pebble of the original Oriskany sandstone. The contact of the sandstone band with the Helderberg is everywhere sharp and clearly defined in marked contrast with the merging contact between the sandy band in the Onondaga above. Sometimes the fine sand penetrates downward into small joints in the Helderberg a short distance. The thin basal sandstone, which I include in the Onondaga formation because of the presence in it of Onondaga fossils, has perhaps its average development at Splitrock. In some areas, however, it is wanting or represented only by a mere film of sand at the contact of the Onondaga and Helderberg. The quarries near Manlius, N.Y., show the minimum development of this sandy band. In some of the Manlius quarries there is no sandstone band at the base of the Onondaga, and fragments of the basal band of this limestone afford no evidence of the presence in them of sand until dissolved in acid, when a small residue of very fine sand is left. The exact line of contact between the Onondaga and Helderberg is easily recognized in the Manlius quarries, where the sandstone is absent, owing to contrast in the appearance of the two limestones. The latter is a fine-textured, hard, dark-blue limestone with few fossils and no crinoid stems, while the Onondaga limestone is a light-gray, coarsely subcrystalline, crinoidal limestone with numerous corals. Some of the corals are of rather large size. One *Favosite* was observed having its base resting on the basal stratum of the Onondaga which has a diameter of 1 ft. Evidence of the disconformity at the contact of these limestones is sometimes distinctly seen in its irregular and angular character, as shown in the photograph (Fig. 1), taken at a quarry one-fourth mile northeast of Manlius. The evenly-bedded Helderberg is here trenched by a shallow troughlike depression about 8 in. in depth, on the side of which the blade of the hammer is seen resting in the photograph (Fig. 1). No trace of residuary clay remains in the Manlius region at the base of the Onondaga, even where eroded depressions like the one shown in Fig. 1 might

be expected to retain it. The Onondaga limestone, however, shows some inclusions in its basal strata of fragments of the Helderberg which were less readily removed by wave action than the subaerial clays which the advancing Onondaga sea must have swept away to other areas. While angular contacts, like the one shown in the figure, are not uncommon, the more usual character of the contact is a horizontal line which affords evidence neither for nor against unconformity with subaerial erosion. It should be pointed out, however, that adjacent disconformable beds, showing no discordance in dip, may have junction over a limited

FIG. 1.—The disconformity between the Onondaga limestone and limestone of the Helderberg group at Manlius, N.Y. The hammer rests on the older formation.

area in a flat plane which represents a considerable amount of subaerial erosion. Even limestones which have experienced the extensive erosion of the present cycle of subaerial degradation in New York may still retain a horizontal upper surface over a limited area. Some of the quarry sections near Manlius, N.Y., show that the contact of the Helderberg and the superposed residuary clay meet along a perfectly horizontal line, although erosion has removed from this particular area many hundreds of feet of rocks.

While the Onondaga limestone rests on the Helderberg, or a thin band of sandstone which, like that at Splitrock, belongs to

the Onondaga over considerable areas in central New York, the Oriskany sandstone is present in many districts. The irregular distribution and great variability in thickness of the Oriskany seem to indicate that the widely scattered patches of the formation represent the remnants of the formation which have been left by the cycle of subaerial erosion which preceded Onondaga deposition. These scattered patches of the Oriskany vary in central New York from 1 ft. or less to 18 or 20 ft.[1] in thickness. The latter thickness

FIG. 2.—Contact of Oriskany sandstone and Onondaga limestone near Jamesville, N.Y. The end of the hammer handle marks the top of the Oriskany and rests upon the etched surfaces of the uppermost band of the Oriskany fossils.

has been reported for the Oriskany on the east side of Skaneateles Lake by Schneider. The contact of the Onondaga and the Oriskany is well exposed in the vicinity of Jamesville, N.Y. In the cliffs near the lake, one-half mile northeast of town, the Oriskany is represented by 30 inches of hard, dark-gray, quartzitic sandstone containing *Spirifer arenosus* and other Oriskany fossils. The

[1] Philip Schneider, *Notes on the Geology of Onondaga County, N.Y.* Syracuse, N.Y.: privately printed, 1894. Pp. 47.

C. C. Wheelock, "The Oriskany Sandstone," *Proc. Onondaga Acad. Sci.*, I (1903). 43.

J. M. Clarke and D. D. Luther, "Geologic Map of the Tully Quadrangle," *Bulletin New York State Mus.*, No. 82 (1905), p. 43.

stratum of the Onondaga limestone immediately above the Oriskany in this section contains a considerable amount of sand, as it does at Splitrock where the Oriskany is absent. The large and numerous Oriskany fossils cease abruptly at a definite plane a little below the top of the arenaceous beds and thus indicate precisely the top of the Oriskany. The sandy element of the basal beds of the Onondaga limestone disappears within from 4 to 10 in. of the top of the Oriskany. The contact of the two formations and the large Oriskany fossils in the lower formation which project beyond the surface of the weathered sandstone are shown in the photograph (Fig. 2). Southwest of Jamesville one-half mile, at the cascade west of the reservoir outlet, the thickness of the Oriskany is about twice that seen in the lake cliffs northeast of town. The section exposed at this point shows:

JAMESVILLE SECTION

	Ft.
Light-gray limestone with corals and other fossils (Onondaga)	7
Hard dark-colored sandstone cemented with lime and holding Oriskany fossils (Oriskany)	6
Thin and evenly bedded dark lead-gray limestone (Helderberg)	15

The Onondaga limestone forms the top and the Helderberg the bottom of the fall. The characteristic chert lenses will be noted in the Onondaga limestone above the hammer in the photograph (Fig. 3).

West of the Finger Lake region the disconformity at the base of the Onondaga eliminates from the section not only the Schoharie and Esopus but the Helderberg as well, letting the Onondaga rest in the western part of the state upon rocks of Silurian age.

Western New York.—The disconformity which marks the break in sedimentation between the Silurian and Devonian systems in western New York is very plainly indicated by both the physical and the faunal evidence in the vicinity of Buffalo. The contact of the Cobleskill and Onondaga limestones is marked by an irregular line in the Falkirk cement quarries and in many other places in the same region. One of the localities where eroded depressions in the Cobleskill may be seen at the base of the Onondaga is in the rock cut of the Lake Erie & Western R.R. near its intersection

with Main Street in northeast Buffalo. Here the abruptly undulating line of separation between the Onondaga limestone and the subjacent Cobleskill is frequently marked by a band of clay or shale a few inches in thickness. In the quarry of the Buffalo Cement

FIG. 3.—Oriskany sandstone and adjacent beds of the Onondaga limestone and limestone of the Helderberg group southwest of Jamesville, N.Y., ½ mile. Lower end of hammer handle marks the top of the Oriskany. The Helderberg forms the foot of the fall.

Company small caverns appear to have been developed in the Cobleskill during the land interval at the end of Silurian time. These contain sand fillings which have been described by Dr. J. M. Clarke.[1] At the cement quarries near Akron a thin band of blue

[1] *Memoirs New York State Mus.*, No. 3, III (1900), 98.

clay or dark shale generally marks the unconformity. The following section just north of Newmans Akron Cement Works will show the character of the unconformity here.

NEWMANS CEMENT WORKS SECTION

	Ft.	In.
Onondaga—		
Limestone and black chert	6	
Gray coralline limestone	4–5	
Dark coffee-colored calcareous shale		2
Corals and dark shale		4
Interformational clay—		
Bluish gray shale, much like clay, with limestone pebbles		1
Cobleskill—		
Drab-colored magnesian limestone	4–6	

Fig. 4 shows the highly irregular and uneven character of the eroded surface of the Cobleskill on which the Onondaga was deposited. At the large quarry, 1 mile northwest of Akron, the stripping of the Onondaga limestone down to the top of the Cobleskill has exposed the upper surface of the latter over a surface of several hundred square yards. This shows admirably the irregular hummocky surface which was covered by the sea during the Onondaga submergence. These inequalities in the surface of the Cobleskill rise above the troughs which separate them from 4 to 6 ft. The surface resembles in its irregularity that which may often be seen where the residuary clay has been stripped from a limestone in the process of quarrying.

ONTARIO AND OHIO

The field observations of the writer on the unconformity at the base of the Onondaga limestone include sections in both Ohio and Ontario. But the recent detailed work of Dr. C. R. Stauffer[1] in these areas on the Onondaga and associated beds will make citation of this author's results, together with some supplementary observations of the writer, suffice for this discussion.

Ontario.—The Onondaga limestone west of Buffalo rests either on the Oriskany sandstone or the Salina formation where the Oriskany is absent as far west as Springvale, Ontario. To the westward of Springvale the Onondaga lies disconformably on a

[1] *Bull. Geol. Soc. Am.*, XXIII, 371–76.

limestone bed in the upper part of the Monroe formation, to which Scherzer, Grabau, and others have applied the name Anderdon limestone. This bed holds a peculiar fauna of supposed Silurian age.[1]

In Ontario the relationship of the Oriskany sandstone to the Onondaga limestone seems to have been misunderstood until very recently. Collections and lists of fossils made by the earlier students of the Ontario Devonian purporting to represent the Oriskany have shown a large proportion of Onondaga species. This has led to the generally accepted view that a fauna existed in

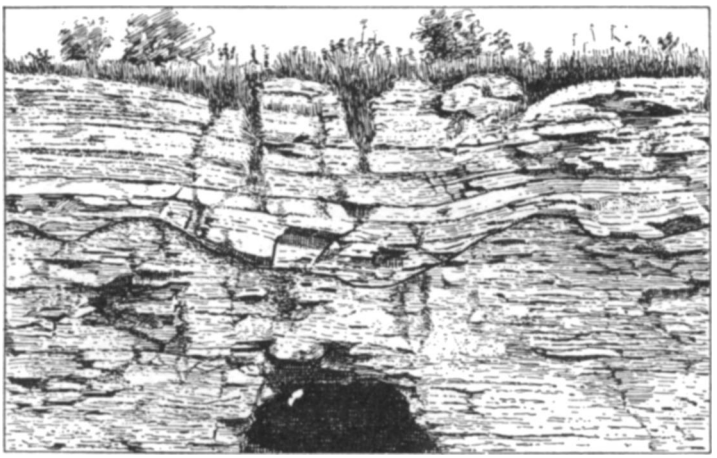

FIG. 4.—The disconformable contact (A–B) of the Onondaga and the Cobleskill limestones at one of the Akron, N.Y., cement mines. From a photograph.

Ontario which was intermediate in character between the ordinary Oriskany and Onondaga faunas. A new formation name—Decewsville formation[2]—was proposed for the beds holding this fauna. Dr. C. R. Stauffer[3] has recently shown that the "Decewsville" fauna of mingled Onondaga and Oriskany affinities has had its origin in the mixing of fossils from adjacent formations. The relationship of Oriskany and Onondaga formations he has found

[1] *Mich. Geol. and Biol. Surv. Pub. 2*, Geol. Ser. (1910), pp. 42–48.

[2] Ulrich and Schuchert, "Paleozoic Seas and Barriers in Eastern North America," *Bulletin New York State Mus.*, No. 52 (1901), p. 653.

[3] *Bull. Geol. Soc. Am.*, XXIII, 371–76.

to be essentially the same in Ontario as it is in New York. The basal beds of the Onondaga are more or less sandy and approach in appearance the Oriskany sandstone below but contain no Oriskany fossils. The Oriskany sandstone is highly irregular both in thickness and in distribution in Ontario as it is in central New York. It is frequently absent from the sections showing the Onondaga limestone. Where it is present it may thin from a thickness of 15 ft. or more to a few inches in a distance of a few rods. This probably results in large part from the Oriskany sandstone filling troughs of erosion in the Salina formation. The accompanying diagram (Fig. 5) shows the relations of the Onondaga limestone and subjacent Oriskany and Salina formations near Decewsville, Ontario. An excavation about 200 ft. northeast of

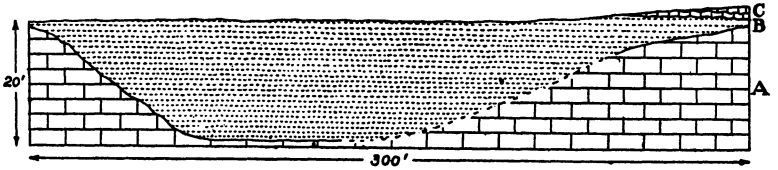

FIG. 5.—Section exposed in vicinity of Oneida Sand Company's quarry, Decewsville, Ont.: A, Salina beds; B, Oriskany sandstone; C, Onondaga limestone.

the Oneida Sand Company's quarry two miles northwest of Decewsville shows the following section:

DECEWSVILLE SECTION

Onondaga limestone	2 ft.
Oriskany sandstone	17 in.
Limestone (Salina formation)	30 ft.+

In the quarry less than 200 ft. from the above section the Oriskany sandstone has thickened to nearly 20 ft., as shown in the diagram. Where the Oriskany is absent the Onondaga-Salina contact is doubtless sometimes as irregular as the Oriskany-Salina contact shown in Fig. 5. But the limited number of good exposures and the absence of quarries where the Oriskany is wanting leave the character of the Onondaga-Salina contact to be inferred from the nature of the Oriskany-Salina disconformity. While the physical evidence of the disconformity at the base of the Oriskany

is more striking than that of the stratigraphic break at the base of the Onondaga limestone, evidence of the latter is not wanting. Stauffer[1] states that good-sized pieces of the sandstone containing Oriskany fossils may be found imbedded in the lower part of the cherty limestone, while at other places not far distant the Onondaga rests directly on the Silurian, with only here and there remnants of the Oriskany lying between.

Ohio.—The fauna of the Columbus limestone, which has been listed by Stauffer,[2] affords satisfactory evidence that this limestone is the Ohio representative of the Onondaga limestone. The fauna, lithology, and stratigraphic relations of the Columbus limestone together furnish unmistakable evidence of its identity with the Onondaga limestone. The disconformity at the base of the Columbus limestone has been described by Dr. Stauffer as follows:

> The Middle Devonian of Ohio naturally falls into three divisions, of which the lowermost is known as the Delaware limestone and the upper as the Olentangy shale. This division is based on both lithological and faunal differences which in some respects are more apparent in the vicinity of Columbus, although not wanting in any of the belts of outcrop. . . . .
>
> The base of the Columbus limestone rests upon the Monroe formation; this contact being that between the two great systems, the Silurian and the Devonian. There is thus a great time gap or unconformity, between these two formations, which is strikingly illustrated by the decided change in character and abundance of animal remains. In some localities the lowest layers of the Columbus contain an abundant fauna which in many respects resembles that of the upper part of the same formation, but where these lower layers have been observed in Franklin, Delaware, and Union counties, a basal conglomerate is found which consists of large and small water-worn pebbles of the underlying formation imbedded in a matrix of Columbus limestone. Where this conglomerate is developed few fossils are found; probably because the organic remains, which existed in these localities at the time the layers in question were being deposited, were ground to a shapeless mud by the continuous action of the waves among the pebbles of a rocky coast. This conglomerate was formerly supposed to represent the Oriskany sandstone of New York, and was so mapped by the geologists who made the first county reports, as well as by Newberry himself; but, since this basal conglomerate

[1] *Bull. Geol. Soc. Am.*, XXIII (1912), 373.

[2] C. R. Stauffer, "The Middle Devonian of Ohio," *Bull. Ohio Geol. Survey*, No. 10. (1909), pp. 160–70.

is not continuous and has not been proven to be Oriskany, it has been customary of later years, and perhaps wisely, to drop the Oriskany sandstone from the Ohio scale and include these deposits with the Columbus limestone to which they are at least very closely related.

It will be noted in the description of this disconformity in Ohio that it is characterized locally, as in central New York, by a conglomerate. This is particularly well developed in the central Ohio region near Columbus, where according to Dr. Stauffer[1] decided evidence of the erosion period which intervened is found in the well-developed basal conglomerate of the overlying Columbus limestone.

INDIANA

Ohio valley.—The Columbus limestone of central Ohio and the Onondaga of New York are represented in southern Indiana by a limestone which bears the closest resemblance to them faunally. This formation has been named in Indiana the Jeffersonville limestone. It is the lowest formation of the Devonian as developed at the Falls of the Ohio. This formation has been shown to hold the same fauna and to be the equivalent in the Ohio valley of the Onondaga limestone of New York.[2] It lies between the Sellersburg limestone and the Louisville limestone of Silurian (Niagaran) age. This formation has perhaps its most typical development at the Falls of the Ohio just below the city of Jeffersonville, where it has a thickness of about 20 ft. It is a light- or bluish-gray crystalline or subcrystalline limestone, occurring both as a massive and as a thinly stratified limestone.

The fossil coral reef for which the Falls of the Ohio have long been noted occurs in the lower part of this formation. The important rôle played by corals in the formation of this limestone is indicated by the great size attained by some individuals. One *Favosite* (*F. hemisphericus?*) which was measured has a breadth of 5 ft. and a height of slightly more than 2 ft. *Spirifer acuminatus*

[1] "The Devonian Section of Ten Mile Creek, Lucas County," *Ohio Nat.*, VIII (1908), 273.

[2] E. M. Kindle. The Devonian and Lower Carboniferous Faunas of Southern Indiana and Central Kentucky, *Bull. Amer. Pal.*, No. 12 (1899); The Devonian Fossils and Stratigraphy of Indiana; *Ind. Dept. Geol. Nat. Res., 25th Ann. Rept*, pp. 229–763, 31 pls., 1901.

and *Spirifer gregarius* are abundant and characteristic fossils of the upper portion of the formation. The lower part of the Jeffersonville limestone, and the Louisville limestone are well exposed in the Bear Grass Creek quarries just east of Louisville, Ky. The section exposed at the west quarry shows:

LOUISVILLE SECTION	Ft.
1. White to light-gray limestone (Jeffersonville limestone)	10
2. Light bluish-gray argillaceous limestone (Louisville limestone)	35

Although all of the sediments and faunas which, in eastern New York, represent the Helderberg group and Oriskany sandstone are missing between the Jeffersonville and the Louisville limestones, evidence of angular unconformity has not been observed in the River sections. Such evidence has been secured a little farther north, however.

North of the Falls of the Ohio 10 or 15 miles, sections which include the Lower Devonian and Niagaran rocks begin to show a thin bed of rather soft, dark-buff to brownish fine-grained magnesian limestone—the Geneva limestone. This formation lies between the Jeffersonville limestone and the Louisville limestone. It thickens gradually toward the north and reaches its maximum development along Flat Rock Creek. The Geneva limestone is generally a massive light-buff to chocolate-brown saccharoidal magnesian limestone. It varies in lithological characters, however. Along Wyloosing Creek, in Jennings County, it is in part a very hard siliceous limestone and was used at one time for mill stones. The fauna of the Geneva limestone indicates that it is of either Schoharie or Onondaga age;[1] probably the former. At the base of the Geneva unmistakable physical evidence of the hiatus between the Geneva and the Louisville limestones has been obtained. An outcrop on the east side of Flat Rock Creek at the ford about 1½ miles above Geneva shows this disconformity. The section exposed at this point is:

FLAT ROCK CREEK SECTION	Ft.	In.
1. Brownish dolomitic saccharoidal limestone (Geneva limestone)	3	
2. Hard light-gray limestone (Louisville)	5	6
3. Blue fossiliferous clay with irregular masses of limestone (Waldron shale)	5	
4. Hard gray limestone	15	

[1] E. M. Kindle. *Ind. Dept. Geol. Nat. Res., 25th Ann. Rept.*, pp. 535–58, 1901.

The character of the disconformity between 1 and 2 is shown in the accompanying photograph (Fig. 6). The bed on which the hammer rests is No. 2 of the above section. This disconformity is also seen in the William Avery quarry on the east side of Conn's

FIG. 6.—The disconformity between the Devonian and Silurian limestones on Flatrock Creek, Shelby Co., Ind. The hammer rests upon the top of the Silurian limestone.

Creek about 1 mile below Waldron, where it is marked by a band of residuary clay in the following section:

CONN'S CREEK SECTION

	Ft.	In.
1. Brownish-buff sandy-looking limestone	2	6
2. Clay		1
3. Blue limestone in 3- to 6-in. layers	5	6

Between the area in the Ohio valley in which outcrops of the Devonian limestone are abundant, and the Wabash valley, where they are also common in a limited district, an extensive drift-covered plain intervenes in which but two or three outcrops of Devonian rocks are known.

Wabash valley.—The Devonian limestones of the Wabash area are differentiated both faunally and lithologically into two divisions, as in the southern part of the southern Indiana area. These two divisions are correlated respectively with the Sellersburg limestone and the Jeffersonville limestone. The Sellersburg formation of the Wabash area contains a Hamilton fauna. It varies from a bluish-drab limestone breaking with subconchoidal fracture to a dark

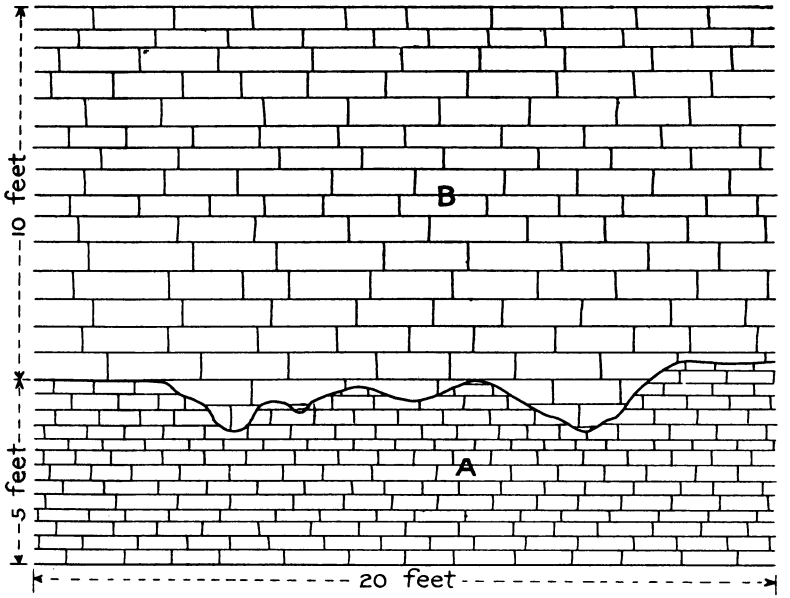

FIG. 7.—Irregular contact line between the Devonian limestone (B) and the Silurian limestone (A) on the bank of the Wabash River, Georgetown, Ind.

argillaceous limestone. *Spirifer pennatus* is the most abundant and generally distributed species.

The formation corresponding to the Jeffersonville limestone at the Falls of the Ohio is a gray crystalline, thin to heavy bedded limestone. This limestone carries a fauna similar to that of the same formation in southern Indiana, and has as one of its most characteristic species *Spirifer acuminatus.* This limestone is unconformable with the Silurian limestone on which it rests. In the other areas in which the stratigraphic break at the base of the Onondaga and its western equivalents has been discussed

there is no discordance in the dip of the strata on the two sides of it, but in the Wabash valley discordance between the Silurian and Devonian limestones is distinctly marked at many outcrops. In this area the term clino-unconformity recently proposed by Professor Crosby[1] is applicable. The Silurian rocks at many points are highly tilted, while the Devonian beds lie nearly horizontal, thus

FIG. 8.—Showing discordance in dip of the Devonian and Silurian limestones at Pipe Creek Falls in northern Indiana.

affording unequivocal evidence of unconformity. Away from the immediate vicinity of the small local domes in the Niagara strata, however, the discordance between the Devonian and Silurian limestones, though slight, can easily be detected with careful observation. Sometimes, however, the discordance is not noticeable.

Just below Georgetown both the Silurian and the Devonian are exposed on each side of the Wabash River. From 5 to 8 ft. of gray crystalline Jeffersonville limestone rests on irregularly eroded Silurian limestone. The line of contact between the two is an

[1] *Jour. Geol.*, XX (1912) 296.

uneven one, frequently rising or sagging on the north side of the river, as shown by the sketch (Fig. 7), but without indicating discordance of dip. On the opposite side of the river the Niagara dips from 6 to 18 degrees to the east, while the Devonian limestone lies horizontal above it, thus indicating deformation as well as erosion previous to the Jeffersonville submergence and showing the relationship of clino-unconformity. The photograph (Fig. 8) indicates this discordance in the dip of the two formations. The Jeffersonville limestone with *Spirifer acuminatus* as its most abundant fossil is the only division of the Devonian here.

The Oriskany sandstone is absent from the Indiana sections. A sandstone known as the Pendleton sandstone resembles it in physical characters, and forms the base of the Devonian section at Pendleton, where it has a thickness of about 7 ft. The fauna of this sandstone, which is wholly unlike the Oriskany, has led to its correlation with the Schoharie grit of New York.

TIME INTERVAL REPRESENTED

The time interval represented by the hiatus at the base of the Onondaga and its western equivalents varies widely in different parts of the area which has been discussed. In the Wabash valley it marks the break between the Silurian and Devonian systems, while in parts of Ontario and New York a far briefer period within the limits of the Devonian system alone is represented. In the western area the time interval may be stated in terms of missing formations. These include the Salina, at the summit of the Silurian, and at the base of the Devonian the Helderberg limestone and the Oriskany sandstone. In New York and Ontario the relationship of the Onondaga and subjacent beds is of the character designated as a disconformity by Dr. Grabau, the beds showing no discordance of dip on the two sides of the unconformity. In northern Indiana, however, there is in some sections distinct though moderate discordance between the unconformable beds, or clino-unconformity.

The place of the longest time interval represented by the stratigraphic break at the base of the Onondaga and its western equivalents as measured by missing formations coincides with the area

in which discordance of dip exists between the unconformable beds. This is limited to the Cincinnati geanticlinal region of northern Indiana. From this area in the Wabash valley of the maximum length of the stratigraphic break at the base of the Jeffersonville limestone, it decreases more or less regularly eastward by the appearance between the Silurian limestone of Guelph age and the Devonian limestone of Onondaga age of the successively younger formations known respectively as the Salina formation, the Cobleskill limestone, the Roundout limestone, the Manlius limestone, and the Oriskany sandstone. With the exception of the last-named formation the western border of each of these lies well to the eastward of the preceding, thus suggesting a shore line retreating eastward during late Silurian and early Devonian time. The distinctive feature of the Oriskany in the New York–Ontario region is its discontinuous character. The western extension to Ontario of Oriskany sediments in irregular patches representing erosion remnants indicates that the easterly retreat of the shore line was reversed about the close of Helderberg time and a submergence of the land occurred in Oriskany time which carried its sediments westward as far as Ontario. Apparently the easterly retreat of the shore line which was reversed with the beginning of Oriskany sedimentation never passed to the eastward of the Hudson River valley in southeastern New York, for no evidence has been found in that region of a stratigraphic break at the base of either the Onondaga or the Oriskany. The disconformity which marks the base of the Onondaga is closely related in space and time with that below the Oriskany.

The erosion of the Oriskany has given it a discontinuous distribution over an area extending from the Hudson River to the middle of southern Ontario. This has resulted in merging the post-Oriskany and pre-Oriskany disconformities into a single disconformity horizon separating the Onondaga and Silurian strata where the Oriskany has been removed.